Genij Ortopedii. 2022. Vol. 28, no. 1. P. 18-23.

**Original article**

https://doi.org/10.18019/1028-4427-2022-28-1-18-23

# *Comparative analysis of clinical outcomes of rotator cuff sutures and their dependence on the methods of cuff fixation*

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***Abstract***

Partial or full-thickness rotator cuff tear is one of the leading causes of pain and dysfunction in the shoulder joint. Despite the variety of existing surgical techniques, the incidence of re-ruptures after surgical treatment, according to MRI studies, varies from 20 % to 39 %. **Purpose** To evaluate and compare the clinical results of full-thickness rotator cuff tears surgical treatment using various methods of tendon fixation. **Materials and methods** A retrospective analysis of case histories, surgery protocols and interviews of patients who underwent surgical treatment for rotator cuff tears at the Krasnoyarsk Regional Clinical Hospital within a period of 6 years was carried out. The sample consisted of 120 patients. All patients were divided into three groups depending on the method of fixation: 1) SutureBridge technique using anchors, 2) classic double-row transosseous suture, 3) double-row transosseous suture using extracortical fixators (Endobutton, Fliptack). **Results** In the first group, excellent and good results were obtained in 72.86 % and poor results were observed in 18.57 %. In the second group, excellent and good results were obtained in 66.66 % of cases, unsatisfactory results in 18.18 %. In the third group, excellent and good results were obtained in 76.47 %, there were no poor outcomes. The best clinical results were obtained in the group of patients who underwent postoperative rehabilitation. **Conclusion** Anchor SutureBridge technique and classical transosseous suture technique demonstrate comparable long-term outcomes. The absence of poor outcomes in the group of extracortical fixators makes further study of this method promising and should be shown in a larger sample.

***Keywords***: rotator cuff, rotator cuff tear, transosseous suture, bone-tendon suture, anchor suture

***For citation***: Denisova A.Yu., Galov A.A., Danilov A.V., Narkevich A.N., Serova E.V. Comparative analysis of clinical outcomes of rotator cuff sutures and their dependence on the methods of cuff fixation. *Genij Ortopedii*, 2022, vol. 28, no 1, pp. 18-23. https://doi.org/10.18019/1028-4427-2022-28-1-18-23

## INTRODUCTION

Among the causes of pain and dysfunction in the shoulder joint, partial or complete rotator cuff tears (RCT) take currently one of the first places [1–5]. The biomechanical role of the rotator cuff is to maintain the congruence of the articular surfaces of the shoulder joint. In the event of a rupture of one of its four tendons, the stabilization of the head in the glenoid cavity of the scapula becomes disturbed resulting in pain, shoulder-scapular osteoarthritis, and progressive loss of the upper limb function [6]. The tear is most often caused by trauma or repetitive microtrauma in combination with a long-term impingement syndrome, leading to degenerative changes in the tendons [7, 8]. According to a British study in 2014, its incidence is 87 cases per 100,000 a year. Most often this pathology occurs in women in the age group of 55–59 years [9]. Among anatomical findings, the RCT is, according to various sources, from 5 to 40 % [8, 10]. Many risk factors are involved, ranging from genetic and anatomical predisposition to smoking and alcohol abuse [7, 9, 11–13]. The most significant correlation is noted with age, starting from 4 % of asymptomatic ruptures in the age group under 40 years old up to 54 % in the age group over 60 years old [11, 14, 15].

Currently, surgical repair of RCT has a history of 110 years. In 1911, E.A. Codman was the first to describe end-to-end supraspinatus tendon suture [16] that over time progressed to a novel fully arthroscopic fixation technique. For a long time, starting from the 40s of the 20th century, the "gold standard" surgical technique was a transosseous suture thanks to the works of H.L. McLaughlin that was performed in conjunction with acromioplasty according to C.S. Neer [17–20]. In 1986, the American surgeon E.M. Goble and engineer W.K. Somers developed and patented the first anchor [21, 22]. A few years earlier M. Wiley and M. Older developed an arthroscopic technique for examining the shoulder joint [23]. The developments together allowed, after almost 10 years of research and observation, to propose a fully arthroscopic method for restoration of the integrity of the RC tendons. In order to provide the strength equivalent to a transosseous suture, the arthroscopic surgical technique has evolved from a simple single-row anchor suture to Arthroscopic Transosseous-Equivalent (TOE) or Suture Bridge repair. Single- and double-row anchor suture, according to numerous studies, loses to a simple transosseous suture in fixation strength [24–29], and the TOE

technique proposed in 2006 by Maxwell C. Park shows comparable strength characteristics [26, 27, 30, 31].

However, specific complications arising from the use of anchors, such as reaction to the implant, its migration, instability in the porous bone, osteolysis in the area of anchor placement, difficulties in revision surgery, combined with the high cost of the materials, have led to a renewed interest in the classic transosseous suture in the last 15 years and attempts to find a solution for its arthroscopic implementation [32–37]. Currently, ArthroTunneler (Tornier, Edina, MN, USA) and OmniCuff (MinInvasive Ltd, Magal, Israel) have been used for these purposes, showing good clinical results [1, 38–40]. Nevertheless, despite the variety of existing surgical techniques, the rates of repeated RC ruptures after suture, according to MRI studies, range from 20 to 39 %, and in the case of massive tears from 41 to 94 % [14]. The conflicting results of studies of various methods of tendon fixation do not allow come to a single standard surgical tactics. Therefore, the choice of a surgical method is always individual and is determined by both technical and, often, economic factors [41, 42].

The **purpose** of the work was to evaluate and compare the clinical results of surgical treatment of full-thickness rotator cuff tears using various methods of tendon and bone fixation.

## MATERIALS AND METHODS

The study is a retrospective analysis of case reports, protocols of operations and a survey of patients that underwent surgical treatment for "rotator cuff tears" at the Krasnoyarsk Regional Clinical Hospital (Krasnoyarsk). The study period was 6 years (2014–2019). The sample was compiled from the database of the qMS software program: the query parameter is the diagnosis code according to ICD-10 S46.0 "Injury of the tendon of the rotator cuff of the shoulder." Exclusion criteria: partial tears, massive irreparable ruptures, tears associated with an avulsion fracture of the greater tubercle of the humerus, tears due to calcifying supraspinatus tendonitis.

In the course of the study, the RCT suture was performed by one surgical team using three surgical techniques: 1) Suture Bridge technique using anchors (hereinafter – A), 2) double-row transosseous suture with lavsan thread with distal fixation on the anchor (hereinafter – TOS), 3) double-row transosseous suture with strengthening of the first row of sutures on extracortical fixators (Endobutton, Flipptack) (hereinafter referred to as TOS+). Since the purpose of the study was to assess the reliability of tendon fixation using various surgical techniques, the method of performing surgical approach, arthrotomy or arthroscopy, was not taken into account. However, the majority of the interventions were open technique (96.6 %). If indicated, the RCT suture was supplemented with subacromial decompression and tenodesis of the long head of the biceps. In the postoperative period, all patients were recommended a standard management protocol: rigid immobilization of the limb in a Dezo or Weinstein plaster cast for 4 weeks, subsequent rehabilitation in a rehabilitation center that included exercise therapy, mechanotherapy, and massage.

Suitable to inclusion parameters were 120 patients, who were divided into 3 groups depending on the surgical technique: group A of 70 people (58.3 %); TOS group of 33 people (27.5 %); and TOS+ group of 17 patients (14.2 %). Males were 59.2 % (71 patients) and females were 40.8 % (49 women), the median age of patients at the time of surgery was 59.0 [52.8; 64.0] years. Considering the territorial space of the region (Krasnoyarsk Territory), it is difficult for patients to attend face-to-face examinations, and therefore, within the framework of this study, it was decided to communicate by telephone. All respondents were informed about the purpose of the survey and agreed to participate in it. Patients were asked standard questions:

1) Was there a history of trauma? 2) Time elapsed from injury to surgery? 3) Was there rehabilitation in the postoperative period? 4) Was there a subjective evaluation of the result of the operation at the present time?

Based on the answers, the results were rated:

a) excellent result: the patient does not experience any difficulties in daily activities, copes with sports loads; there is no limitation in the range of motion or pain in the shoulder joint;

b) good result: there is no restriction of movements, no difficulties in daily activities, but there is occasional pain during / after physical exertion, “for the weather change”, which do not require medication;

c) fair result: the patient does not cope with intense physical activity, but has no difficulties at the household level;

d) poor result: the patients has difficulties in self-care or there is recurrence of RC rupture, requiring repeated surgical intervention.

Statistical analysis of the obtained data was carried out using the statistical package IBM SPSS Statistics v.19. The normality of the distribution of quantitative data was assessed using the Shapiro-Wilk test. Due to the fact that all quantitative data did not obey the normal distribution law, they are presented as a median, first and third quartiles (Me [Q1; Q3]). Qualitative features are presented as relative frequencies expressed as a percentage (%). Comparison of qualitative signs between groups of patients was carried out using the Chi-square, Chi-square with Yates correction and Fisher's exact test, depending on the value of the expected frequencies when constructing contingency tables. Differences between groups were considered statistically significant at $p < 0.05$.

## RESULTS

The median time from injury to surgery was 7.0 [4.0; 11.0] months. According to this parameter, three groups were formed: 1) up to six months, 2) from 6 months to a year, 3) a year or more. In the first group, the indicator of poor results was 11.8%, and 49.0 % were excellent. In the second group, poor results were obtained in 15.8 % and an excellent result in 42.1 %. In the third group, poor results made 14.3%, and excellent ones were 42.9 % (Fig. 1). There were no statistically significant differences in the corresponding results of surgical intervention in these groups ($p > 0.05$).

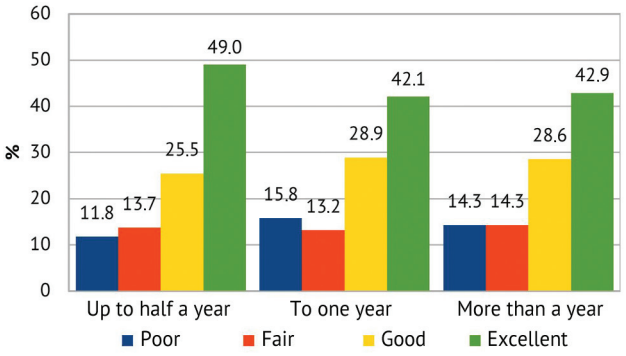


**Fig. 1** Long-term results depending on the time from the moment of injury to surgery

In total, 48.3% of respondents (58 patients) underwent rehabilitation in the postoperative period. Of these, good and excellent results were obtained in 77.8 % (44 patients), and poor ones in 13.3 % (6 people). In the group of those who did not undergo rehabilitation (62 subjects), good and excellent results were obtained in 68.0 % (44 patients, $p = 0.545$), poor in 17.3 % of cases (13 patients; $p = 0.179$) (Fig. 2).

The median age at the time of surgery in group A was 59.0 [52.0; 66.5] years ($p_{TOS-A} = 0.885$; $p_{TOS+-A} = 0.810$). 41.4 % (29 subjects) of treated patients underwent rehabilitation. Excellent and good results were obtained in 72.9 % ($p_{TOS-A} = 0.519$; $p_{TOS+-A} = 1.000$), satisfactory in 8.6 %, and poor in 18.6 % (13 patients; $p_{TOS-A} = 0.962$; $p_{TOS+-A} = 0.063$) cases.

The median age at the time of surgery in the TOS group was also 59.0 [52.0; 64.0] years. Rehabilitation was completed in 42.4 % (14 patients). Excellent and good results among patients of the TOS group were obtained in 66.7 % of cases, satisfactory in 15.2 %, poor ones in 18.2 % (6 cases).

The median age at the time of surgery in the TOS+ group was 61.0 [55.0; 64.0] year ($p_{TOS-TOSH+} = 0.637$). Of these, rehabilitation was completed by two patients (11.8 %). The rate of excellent and good results was 76.5 % ($p_{TOS-TOS+} = 0.540$), of satisfactory ones – 23.5 %, there were no poor results ($p_{TOS-TOSH+} = 0.083$). The overall results are shown in Figure 3.

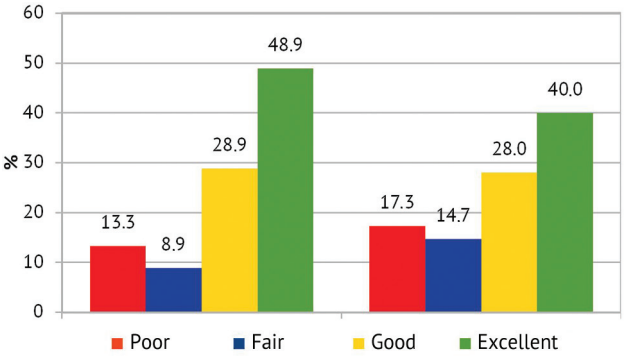


**Fig. 2** Results depending on rehabilitation in the postoperative period

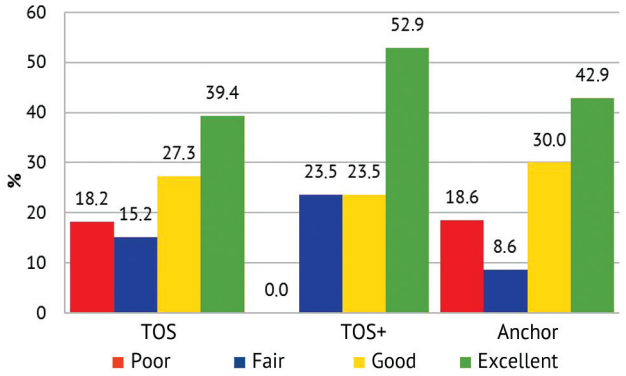


**Fig. 3** Long-term results depending on the fixation type: TOS – transosseous suture; TOS+ transosseous suture with extracortical fixator, anchor – anchor suture

## DISCUSSION

No statically significant difference was obtained by analyzing the effect of waiting time for surgery after an injury on the long-term clinical result. In all groups, there were almost comparable rates of both positive and negative results.

Assessment of the results in regard to presence or absence of rehabilitation measures in the postoperative period did not give a statistically significant result ($p > 0.05$). However, in the rehabilitation group, there is a lower rate of poor outcomes, and excellent results were observed in a larger number of cases.

According to the data obtained, anchoring in the Suture Bridge technique and the classical transosseous suture showed comparable results, what is consistent with the results of well-known studies. Given the fact that the transosseous suture is economically much less expensive, and with proper experience it does not present great technical difficulties, management of patients with RC ruptures may be expanded geographically what reduce the waiting time for surgery, and for patients of working age, the duration of disability.

The result was unexpected in the TOS+ group, in which not a single poor outcome was obtained. We did not find any literature report on such a modification of the bone-tendon suture by supplementing it with extracortical fixators as a support platform. Initially,

this technique was developed in the process of performing a transosseous suture on a porous bone, when the bone was cut with lavsan threads. To prevent possible complications, the proximal row of sutures was performed using the ENDOBUTTON extracortical fixator in order to evenly distribute the load on the bone surface. In the TOS+ group, the results were close to statistically significant, and, perhaps, it will be possible to prove the reliability of the excellent results obtained on a larger sample. This method does not have any contraindications other than the standard contraindications for performing a transosseous suture and the use of extracortical fixators. The relative disadvantages of the method include possible difficulties with MRI control in the postoperative period due to metal parts. Also, the use of suture buttons significantly increases the cost of a transosseous suture, nevertheless leaving it cheaper than anchor fixation. The use of this method is expected in situations where the quality of the bone does not exclude the possibility of thread eruption after performing a lavsan suture and insertion of anchors due to the prospect of their further instability.

Studying the case histories, we encountered the practice of a simplified diagnosis for this pathology, which in most cases sounded like a "rotator cuff tear". Currently, there is no single requirement for the formulation of RCT diagnosis. However, we consider it appropriate to introduce the practice of formulating a detailed diagnosis based on modern classifications. This will enable to subsequently carry out a retrospective analysis of one's own work, draw up a plan for surgical intervention at the preparatory stages, and also analyze postoperative complications. This is especially true for situations in which the physician that refers the patient for surgical treatment, the operating surgeon and the specialist involved in the postoperative management is not the same person. Moreover, such practice will allow integrating the results of our own work and the results of modern domestic and foreign research. Tables 1–6 present the main characteristics of RCT which, in our opinion, should be present in the final postoperative diagnosis.

Table 1

H. Ellman and Gartsman classification (1993) of tears shape

| | |
|---|---|
| 1 | Crescent |
| 2 | Reverse L-shaped |
| 3 | L-shaped |
| 4 | Trapezoidal |
| 5 | Massive tear |

Table 2

R.H. Cofield classification (1982) of tear area

| | |
|---|---|
| 1 | Small < 1cm |
| 2 | Medium 1–3 cm |
| 3 | Large 3–5 cm |
| 4 | Massive > 5 cm |

Table 3

Cuff tear retraction: D. Patte classification (1990)

| | |
|---|---|
| Stage1 | Proximal stump close to bony insertion |
| Stage 2 | Proximal stump at level of humeral head |
| Stage 3 | Proximal stump at glenoid level |

Table 4

Fatty degeneration of cuff muscles according to Goutallier classification (1994 г.)

| | |
|---|---|
| Stage 0 | Normal tendon |
| Stage 1 | Some fatty streaks |
| Stage 2 | Less than 50 % muscle atrophy |
| Stage 3 | 50 % fatty mucle atrophy |
| Stage 4 | Greater than 50 % fatty muscle atrophy |

To assess concomitant shoulder-scapular osteoarthritis, it is necessary to use the classification of K. Hamada (1990) [43], which is based on the acromiohumeral interval (AHI).

Table 5

Classification of K. Hamada (1990)

| | |
|---|---|
| Grade 1 | AHI > 6 мм |
| Grade 2 | AHI < 5 мм |
| Grade 3 | Concave deformity of the acromion (acromial acetabulization) |
| Grade 4 | Joint narrowing |
| Grade 5 | Humeral head collapse |

To assess the postoperative results of the PC suture, there are 5 types of bone-tendon integration proposed by H. Sugaya (2005) [44].

Table 6

Types of bone-tendon integration according to H. Sugaya (2005) [44]

| | |
|---|---|
| Type I | The tendon has a homogeneous structure, sufficient thickness, comparable to the contralateral tendon, the same low-intensity signal on all sections |
| Type II | Sufficient thickness of the tendon, comparable to the contralateral, there are areas of high-intensity signal |
| Type III | Insufficient thickness of the tendon compared to contralateral one but without discontinuity |
| Type IV | Minor full-thickness tendon discontinuity on one or two sections simultaneously in the oblique-coronary and sagittal planes indicates an incomplete re-rupture of the tendon |
| Type V | Major tendon discontinuity, traced on more than 2 sections simultaneously in the oblique-coronary and sagittal planes, indicates the failure of the suture and a complete re-rupture of the tendon |

## CONCLUSIONS

The best clinical results are observed if rehabilitation measures in the postoperative period are followed.

Anchor fixation with the Suture Bridge technique and the classical transosseous suture show comparable long-term clinical results.

The low cost and relative technical simplicity of the transosseous suture enable to more widely provide care to patients with rotator cuff tears.

Good and excellent results obtained with the use of a transosseous suture reinforced with an extracortical fixator, as well as the absence of poor outcomes in this group, make further research of this method promising.

A detailed diagnosis should be fomulated using modern classifications for competent surgical planning and predicting the postoperative result, for retrospective analysis of the work performed and the possibility to correlate the results of one's own work with the results of domestic and foreign studies.

Further study on a larger sample of patients is required to obtain statistically significant results.

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The article was submitted 17.06.2021; approved after reviewing 21.10.2021; accepted for publication 23.12.2021.

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